Citation:

McKeown NM, Yoshida M, Shea MK, Jacques PF, Lichtenstein AH, Rogers G, Booth SL, Saltzman E. Whole-grain intake and cereal fiber are associated with lower abdominal adiposity in older adults. *J Nutr.* 2009 Oct; 139 (10): 1,950-1,955. Epub 2009 Sep 2

Study Design:

Cross-sectional study

Class:

D - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

- To examine the association between whole and refined grain intake and measures of body fat distribution in older adults (≥60 years)
- To examine the relations between cereal, fruit and vegetable fiber and body fat distribution in study sample.

Inclusion Criteria:

- Participants already enrolled in three-year, double-blind, controlled trial which began in 2002 (examining the effect of vitamin K supplementation on age-related bone turnover, bone loss and vascular calcification)
- No bone or vascular health-related risk factors
- Completed valid food frequency questionnaire (FFQ)
- Had all covariate information.

Exclusion Criteria:

- Bone and vascular health-related factors (described elsewhere)
- Incomplete or invalid FFQ
- Missing covariate information.

Description of Study Protocol:

Recruitment

- Recruited from study population already enrolled in another study. Recruitment method not described.
- Majority of participants recruited were Caucasian (93%).

Design

- Cross-sectional study of 434 (177 men and 257 women) free-living older adults (between 60-80 years) who met inclusion criteria

- Medical history and physical exam were performed by a nurse practitioner
- Dietary intake for items of interest (whole grain, refined grain, dietary fiber and fiber sources; fruit, vegetable and cereal) was estimated using a 126-item semi-quantitative FFQ
- Percent body fat and percent trunk fat mass were measured by whole-body dual-energy X-ray absorptiometry (DXA)
- Study participants were divided into four quartile categories by level of whole and refined grain and dietary fiber and fiber sources.

Dietary Intake/Dietary Assessment Methodology

- FFQs were mailed and completed by participants prior to first appointment where FFQs were reviewed with a study team member
- Usual dietary intake during previous year was estimated at baseline from the FFQ. FFQ was considered valid if reported energy intakes were:
    - ≥600kcal per day for both men and women
    - <4,000kcal per day for women
    - <4,200kcal per day for men
    - Fewer than 13 food items were left blank
- FFQ consisted of a list of foods with a standard serving size and a selection of nine frequency categories ranging from never or less than one serving to more than six servings per day
- For comparison purposes, whole grain was also estimated as grams per day by using product labels and USDA national nutrient database information to calculate whole-grain concentration per food serving on all foods on the FFQ
- The amount of dietary fiber for each food item was calculated and summed into four mutually-exclusive fiber categories (cereal, fruit, vegetable and legume (Note: mean legume fiber intake was low so was not included in sub-group analysis).

Intervention

Not applicable

Statistical Analysis

- Calculated age, sex and energy-adjusted means for lifestyle and dietary characteristics across increasing quartile categories of whole-grain, refined grain, dietary fiber and fiber sources (fruit, vegetable and cereal)
- Assessed significance (P-value <0.05) of trends across categories of intake using linear (for continuous lifestyle and dietary variables) or logistic regression (for dichotomous outcome variables)
- Used general linear models to examine association between dietary intakes and measures of body fat
- For quartile categories, median intake of each quartile was assigned to subjects in the quartile and then included the quartile median variable as a continuous factor in the multiple regressions models
- Controlled for sex, age, total energy intake, percent of energy from fat, physical activity (PA) (using PA scale for the elderly for those aged ≥65 years), smoking status, ethanol (ETOH) intake and multivitamin use in multivariate models
- For independent variables significantly associated with the outcome (i.e., cereal fiber and whole grains), adjusted for the percentage of energy from CHO, fruit fiber and vegetable fiber to decide whether those were independent of other dietary factors
- Tested each association for effect modification by sex and found no significant interaction

so data are presented for women and men combined.

Data Collection Summary:

Timing of Measurements

Dietary (FFQ), anthropometric (height and weight) and biochemical measures (whole-body DXA) were collected at baseline.

Dependent Variables

- BMI, kg/m^2: Height and weight were measured without shoes in light clothing to the nearest 0.1cm for height and 0.1kg for weight
- Percent body fat: Measured by whole-body DXA
- Percent trunk fat mass: Measured by whole-body DXA. Percent trunk fat mass was calculated from the grams of fat and lean tissue in the region of interest (ROI), which was the fat mass between the upper edge of the second lumbar vertebra to above the iliac crest.

Independent Variables

- Whole grain: Questions were asked on frequency of whole-grain foods such as:
  - Dark bread, brown rice, popcorn and other grains (e.g., bulgur, kasha and couscous), cooked and cold breakfast cereals (identified by brand so they could be classified as whole grain if ≥25% whole grain or bran by weight or as refined grain if <25%). To help in identifying if breakfast cereal was whole grain or not, it was classified as missing if brand name was missing
  - Product labels and USDA national nutrient database information were applied to all foods on FFQ and percentage of whole-grain concentration was calculated on a dry weight. Percentage for each food was multiplied by gram weight per serving and expressed in grams per day
- Refined grain: Measured with FFQ (i.e., white bread, English muffins, bagels, muffins or biscuits, white rice, pasta, pancakes or waffles, crackers and pizza). If cereal, <25% whole grain or bran by weight
- Total fiber: Amount of dietary fiber for each food item was calculated and summed into four mutually-exclusive fiber categories: Cereal, fruit, vegetable and legume. Total fiber for each source was expressed as grams per day. (Note: legume was excluded since intake was "low" and so not included in sub-group analysis). Separate questions were added for counting added bran or wheat germ
- Cereal fiber: For cold cereal, subjects were asked to provide brand and type of cereal so they could be divided into ≥25% whole grain or bran by weight (for whole grain) or <25% whole grain or bran (for refined grain). Without brand name, items were classified as missing.
- Fruit fiber: See above under Total fiber
- Vegetable fiber: See above under Total fiber.

Control Variables

- Sex
- Age
- Total energy intake

- Percent of energy from fat
- Physical activity
- Smoking status
- Alcohol intake
- Multivitamin use.

Description of Actual Data Sample:

- *Initial N:* 452 free-living adults (185 men and 267 women)
- *Attrition (final N):*
  - 434 adults (177 men and 257 women)
  - N=6 excluded for not completing FFQ
  - N=9 excluded for invalid FFQ
  - N=3 excluded for missing covariate information
  - Also Note: measurement of abdominal adiposity or trunk fat was only available for 373 participants out of 434 (loss of 61 participants or 8.6%) due to difficulties in getting correct placement for measurement
- *Age:* 68±6 years (range 60-81 years)
- *Ethnicity*: 93% Caucasian
- *Other relevant demographics:* (More likely) below:
  - Characteristics of those with higher intake of whole grains, refined grains or fiber and demographics:
    - Higher intake of whole grains; women, non-smokers, vitamin takers, lower fat intake and higher carbohydrate (CHO) intake, also plus association with energy intake
    - Higher intake of refined grains; men, higher physical activity (PA), plus association with energy intake
    - Higher intake of fiber; women, vitamin takers, higher PA, non-smokers
  - Characteristics of sources of fiber and demographics:
    - Higher intake of fruits and vegetables; women
    - Higher intake of vegetables; higher PA, plus association with ETOH intake, less percent energy from CHO
    - Higher intake of fruits; association with ETOH intake, greater percent energy from CHO in highest quartiles
    - Higher intake of cereal and fruits; vitamin takers, non-smokers, greater percent energy from CHO in highest quartiles
    - Higher intake of dietary fiber, cereal, fruit and vegetable fibers; plus total energy, potassium and magnesium intake, - for energy from total fat greater percent energy from CHO in highest quartiles (except vegetables)
- *Anthropometrics:* See tables in Summary of Results
- *Location*: Human Nutrition Research Center on Aging at Tufts University, Boston, Massachusetts.

Summary of Results:

Multivariate-adjusted Means (95% CI) of Body Weight, BMI and Body Composition Measurements by Quartiles of Whole Grain and Cereal Fiber*

Dependent Variables	Q1 N=108 Whole Grain Median Intake Servings Per Day 0.21	Q2 N=109 Whole Grain Median Intake Servings Per Day 0.86	Q3 N=109 Whole Grain Median Intake servings Per Day 1.57	Q4 N=108 Whole grain Median Intake Servings Per Day 2.86	P-trend 95% CI
BMI Kg/m^2	26.8 (25.7-28.1)	26.8 (25.6-28.10	25.9 (24.7-27.1)	25.8 (24.6-27.10)	0.08
Percent body fat	34.5 (32.7-36.3)	33.4 (31.5-35.3)	32.9 (31.0-34.8)	32.1 (30.1-34.1)	0.02
Trunk fat mass, percent	43.0 (40.4–45.5)	40.3 (37.7–42.9)	39.5 (36.9–42.1)	39.4 (36.7–42.1)	0.02
Dependent Variables	**Q1 N=108 Cereal Fiber Median Intake Grams Per Day 2.4**	**Q2 N=109 Cereal Fiber Median Intake Grams Per Day 4.1**	**Q3 N=109 Cereal Fiber Median Intake Grams Per Day 5.8**	**Q4 N=108 Cereal Fiber Median Intake Grams Per Day 9.3**	**P-trend 95% CI**
BMI Kg/m^2	27.3 (26.1-28.6)	26.5 (25.3-27.7)	26.0 (24.8-27.2)	25.4 (24.2-26.7)	0.01
Percent body fat	34.7 (32.8-36.6)	33.9 (32.1-35.8)	32.8 (30.9-34.7)	31.5 (29.4-33.5)	0.004
Trunk fat mass, percent	42.8 (40.2-45.4)	41.5 (38.9-44.1)	40.2 (37.6-42.8)	37.8 (35.0-40.6)	0.001

*Adjusted for age, sex, total energy intake, percent energy from fat, PA, smoking, ETOH intake and multivitamin use

Other Findings

- Refined grain intake (1.9±1.4 servings per day) not associated with any measure of body fat distribution
- No significant association between intakes of total fiber (18.6±7.6 grams per day), vegetable fiber (5.5±2.7 grams per day), or fruit fiber (4.2±2.9 grams per day) and body composition measurements
- Median intakes of added bran and added germ were 0.39 and zero grams per day, respectively, suggesting these sources were not major contributors to whole-grain intake
- As with two other studies, average intake of whole grains was low in this population of older adults, with average intake approximately 1.5 servings per day
    - Based on servings per week, major dietary sources of whole grain included dark bread (40%), cold breakfast cereal (33%), hot breakfast cereal (19%) and brown rice (7.5%)

- Main sources contributing to cereal fiber included cold breakfast cereal (21%), hot breakfast cereal (11%), dark bread (11%), pasta (10%), English muffins or bagels (7%) and pizza (6%).

Author Conclusion:

- Higher consumption of whole-grain foods was associated in a dose-dependent manner with a significantly lower percentage of abdominal fat as determined by DXA
- No relationship was observed between refined grain intake and measures of body fat
- Did not observe significant association between intakes of total fiber, vegetable or fruit fiber and body composition measurements
- Findings of this study suggest that cereal fiber, in particular from whole-grain products, may have an affect on body fat distribution (total percent body fat and percent trunk fat mass in older adults)
- Further intervention studies are needed to consider how whole-grain foods (rich in cereal fiber) affect the regulation of energy intake and subsequently how different types of grains (and sources of cereal fiber) affect body fat distribution.

Reviewer Comments:

Limitations of study (per authors first):

- *Since this is a cross-sectional study, ability to infer causality between dietary exposures and body fat is limited*
- *Exclusion criteria of parent study may mean that study participants are actually a healthier sample than a typical range of adults aged 60-80 years participating in NHANES (i.e., mean dietary fiber intake in this sample was approximately 19 grams per day compared with approximately 13 grams per day of NHANES sample in this age range*
- *Dietary measurement error may have distorted observed associations (or lack of them) between fiber from fruit and vegetable intake individuals tend to overestimate fruit and vegetable consumption inFFQs*
- *DXA is only a proxy measure of abdominal adiposity and is unable to differentiate subcutaneous fat from visceral although three studies have reported strong correlation between abdominal fat estimated using the specific ROI from DXA (one) and visceral fat measure by MRI and computed tomography (two)*
- *As observational study, while authors adjusted for important potential confounding factors, residual confounding caused by lifestyle factors associated with adiposity may still bias the observed association.*

Other:

- *Main author received funding from General Mills Bell Institute of Health and Nutrition although five other authors contributed to study design and manuscript preparation and all authors approved final version of manuscript*
- *Population 93% Caucasian so may not be able to generalize findings to all ethnic groups*
- *As noted in Attrition section: Measurement of abdominal adiposity or trunk fat was only available for 373 participants out of 434 (loss of 61 participants or 8.6%), due to difficulties in getting correct placement for measurement. This is not mentioned or noted in tables one*

or two or in result, yet the outcome is one of the significant analytical findings of the study.

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	???
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes
Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	???
3.	**Were study groups comparable?**	No
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	N/A

3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	N/A
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	No
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	Yes
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	No
4.1.	Were follow-up methods described and the same for all groups?	N/A
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	No
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	No
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	N/A
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A

6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	N/A
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	N/A
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	???
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	No
8.1.	Were statistical analyses adequately described and the results reported appropriately?	No
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	No

8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	No
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	No
10.	**Is bias due to study's funding or sponsorship unlikely?**	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	???